DECLARATION

I, Dale Robert Hutchinson, c/o MIURA & ASSOCIATES, Nishiwaki Building 4F, 1-4, Kojimachi 4-chome Chiyoda-ku, Tokyo Japan 102-0083, do hereby declare that I am familiar with the English and Japanese Languages and that I believe the annexed is an accurate translation of the certified copy of the Japanese Patent Application No.2003-34082, filed on February 12, 2003.

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Dale Robert Hutchinson

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: February 12, 2003

Application Number: Patent Application No.2003-34082

Applicant(s): PENTAX Corporation

【TITLE OF THE DOCUMENT】 SPECIFICATION

【TITLE OF THE INVENTION】 SWITCHING/MOVING STRUCTURE OF A LENS BARREL

【CLAIMS】

1. A lens barrel switching/moving structure comprising:

a linear guide ring (18) which is supported to be linearly movable only along an optical axis without rotating;

a moving frame (17) having a male helicoid on the outer peripheral surface thereof, said moving frame being supported by said linear guide ring to be linearly movable only along said optical axis;

a rotational ring (15) which is coupled to said linear guide ring at a predetermined relative rotational position to be freely rotatable relative to said linear guide ring without moving along said optical axis relative to said linear guide ring, a female helicoid formed on an inner peripheral surface of said rotatable ring, said female helicoid being engaged with said male helicoid;

a switching ring (16) which is coupled to said rotatable ring at a predetermined relative rotational position to be freely movable along said optical axis relative to said rotatable ring and rotatable together with said rotatable ring, said switching ring being coupled to said moving frame to be

freely rotatable relative to said moving frame without moving along said optical axis relative to said moving frame;

a switching leaf (28) which is supported by said linear guide ring to be freely movable in a circumferential direction of said linear guide ring within a predetermined range of movement without moving along said optical axis relative to said linear guide ring; and

a switching leaf moving groove (16c) which is formed on an inner peripheral surface of said switching ring to be engaged with a follower projection projecting from said switching leaf,

wherein said switching leaf moving groove includes a first inclined section (16cT) in which said switching leaf follower projection, which is shaped so that a lead angle thereof is the opposite of the threads of said female helicoid of said rotatable ring, is inserted; a switching section (16cK) which is shaped to extend parallel to said optical axis from a front end of said first inclined section; a second inclined section (16cW) which is shaped to extend parallel to said first inclined section from a rear end of said switching section; and an assembling section (16cA) which extends rearwards from a front end of the second inclined section to be parallel to said optical axis, in that order from rear of said lens barrel switching/moving structure.

2. The lens barrel switching/moving structure according to claim 1, wherein said moving frame serves as a

first group supporting ring for supporting a first lens group of said lens barrel; wherein the switching leaf is associated with a second/third lens group unit which supports a second lens group and a third lens group, so that forward and reverse movements of said switching leaf in the circumferential direction changes a distance between the second lens group and the third lens group within said second/third lens group unit.

【DETAILED DESCRIPTION OF THE INVENTION】

【0001】

【Technical Field】

The present invention relates to a switching/moving structure of a lens barrel.

【0002】

【Prior Art and Problems Thereof】

A lens barrel, wherein a linear guide ring which is supported to be linearly movable only along an optical axis and a rotatable ring are coupled in a first bayonet manner at a predetermined relative rotational position so that the rotatable ring is freely rotatable relative to the linear guide ring and so that the rotatable ring and the linear guide ring are immovable relative to each other along the optical axis and further wherein a moving frame (lens group support ring) which is supported by the linear guide ring to be linearly movable only along the optical axis and a switching ring which rotates

together with the rotatable ring and which is movable relative to the rotatable ring along the optical axis are coupled in a second bayonet manner at a predetermined relative rotational position so that the switching ring is freely rotatable relative to the moving frame and so that the switching ring and the moving frame are immovable relative to each other along the optical axis, is known in the art. The moving frame is provided on an outer peripheral surface thereof with a male helicoid while the rotatable ring is provided on an inner peripheral surface thereof with a female helicoid which is engaged with the male helicoid of the moving frame. A rotation of the rotatable ring causes the moving frame (which supports the first lens group) to move linearly along the optical axis, and causes lens groups positioned behind the first lens group to move along the optical axis by motion of the cam formed on the rotatable ring.

【0003】

In addition to the above described structure of the known lens barrel, a zoom lens barrel which is currently under development by the assignee of the present invention includes a structure in which a switching leaf is supported by the linear guide ring to be freely movable in a circumferential direction of the linear guide ring within a predetermined range of movement while movement along the optical axis relative to the linear guide ring is restricted, and a switching leaf moving groove is formed on an inner peripheral surface of the switching

ring to be engaged with a follower projection which projects from the switching leaf, so that the distance between the second lens group and the third lens group changes by a movement of the switching leaf in a circumferential direction. The switching leaf moving groove includes a first inclined section (telephoto section) which is shaped so that the lead angle thereof is the same as that of the threads of the female helicoid of the rotatable ring and so that the direction of inclination of the first inclined section is opposite to that of the threads of the female helicoid of the rotatable ring; a switching section which is shaped to extend parallel to the optical axis from the front end of the first inclined section; and a second inclined section (wide-angle section) which is shaped to extend parallel to the first inclined section from the front end of the switching section; in that order from the rear of the zoom lens barrel.

【0004】

However, in a construction having such a switching leaf, it is impossible to carry out the coupling of the above-mentioned two bayonet manners (between the linear guide ring and the rotatable ring, and between the moving frame and the switching ring) and carry out the helicoid coupling of the moving frame and the rotatable ring.

【0005】

【Patent References】

Japanese Unexamined Patent Publication No. 2000-275518

Japanese Unexamined Patent Publication No. 2001-215381

【0006】

【Objective Of The Invention】

The objective of the present invention provides a switching/moving structure which makes it possible to perform the two bayonet manners of coupling, and the helicoid manner of coupling without any difficulties.

【0007】

【Summary Of The Invention】

A lens barrel switching/moving structure of the present invention is provided, including a linear guide ring (18) which is supported to be linearly movable only along an optical axis without rotating; a moving frame (17) having a male helicoid on the outer peripheral surface thereof, the moving frame being supported by the linear guide ring to be linearly movable only along the optical axis; a rotational ring (15) which is coupled to the linear guide ring at a predetermined relative rotational position to be freely rotatable relative to the linear guide ring without moving along the optical axis relative to the linear guide ring, a female helicoid formed on an inner peripheral surface of the rotatable ring, the female helicoid being engaged with the male helicoid; a switching ring (16) which is coupled to the rotatable ring at a predetermined relative rotational position to be freely movable along the

optical axis relative to the rotatable ring and rotatable together with the rotatable ring, the switching ring being coupled to the moving frame to be freely rotatable relative to the moving frame without moving along the optical axis relative to the moving frame; a switching leaf (28) which is supported by the linear guide ring to be freely movable in a circumferential direction of the linear guide ring within a predetermined range of movement without moving along the optical axis relative to the linear guide ring; and a switching leaf moving groove (16c) which is formed on an inner peripheral surface of the switching ring to be engaged with a follower projection projecting from the switching leaf, wherein the switching leaf moving groove includes a first inclined section (16cT) in which the switching leaf follower projection, which is shaped so that a lead angle thereof is the opposite of the threads of the female helicoid of the rotatable ring, is inserted; a switching section (16cK) which is shaped to extend parallel to the optical axis from a front end of the first inclined section; a second inclined section (16cW) which is shaped to extend parallel to the first inclined section from a rear end of the switching section; and an assembling section (16cA) which extends rearwards from a front end of the second inclined section to be parallel to the optical axis, in that order from rear of the lens barrel switching/moving structure.

【0008】

In the lens barrel switching/moving structure of the present invention, the moving frame can serve as a first group supporting ring for supporting a first lens group of the lens barrel; wherein the switching leaf is associated with a second/third lens group unit which supports a second lens group and a third lens group, so that forward and reverse movements of the switching leaf in the circumferential direction can change a distance between the second lens group and the third lens group within the second/third lens group unit.

【0009】

【DESCRIPTION OF THE PREFERRED EMBODIMENTS】

Figure 1 shows a zoom lens optical system provided in an embodiment of a zoom lens barrel according to the present invention. The zoom lens system includes a positive powered first lens group L1, and a negative powered second lens group L2, a positive powered third lens group L3 and a negative powered fourth lens group L4, in that order from the object side. The second lens group L2 and the third lens group L3 serve as a distance-varying lens group (L23) which changes the distance therebetween at an intermediate range of focal length (mode switching section) from a wide distance in a wide-angle range (wide-angle mode section) to a narrow distance in a telephoto range (telephoto mode section) and vice versa. The second lens group L2 and the third lens group L3 integrally move together in each of the wide-angle range and the telephoto range. The

first lens group L1 and the fourth lens group L4 always integrally move together without changing the distance therebetween. Over the entire zooming range from the short focal length extremity (wide-angle extremity (W)) to the long focal length extremity (telephoto extremity (T)), each of the first lens group L1, the distance-varying lens group L23 and the fourth lens group L4 moves uniformly from the image side to the object side. The present embodiment of the zoom lens barrel 10 is a step-zoom lens barrel which changes the focal length stepwise (specifically, six different focal lengths) when performing a zooming operation, and the distance-varying lens group L23 serves as a focusing lens group in the step-zoom lens barrel. Namely, solid lines shown in Figure 1 represent associated cam diagrams which include cam diagrams for a focusing operation. A reference moving path of the distance-varying lens group (focusing lens group) L23 to perform a zooming operation for an object at infinity is represented by one-dot chain lines.

【0010】

This type of zoom lens system having a distance-varying lens group in which the distance between two lens elements varies at an intermediate focal length has been proposed in Japanese Unexamined Patent Publication No.2000-275518, the assignee of which is the same as that of the present invention. This zoom lens system includes a plurality of movable lens

groups which are moved to vary the focal length of the zoom lens system, and at least one of the movable lens groups includes two sub-lens groups serving as a switching lens group. One of the two sub-lens groups is moveable, along the optical axis of the zoom lens system, to be selectively positioned at one of the movement extremities of the moveable sub-lens group with respect to the other sub-lens group. In a short-focal-length side zooming range covering the short focal length extremity over an intermediate focal length, the moveable sub-lens group is arranged to position at one of the movement extremities thereof. In a long-focal-length side zooming range covering the long focal length extremity over the intermediate focal length, the moveable sub-lens group is arranged to position at the other of the movement extremities thereof. The moving path of the switching lens group having the two sub-lens groups, and the moving paths of the other lens groups of the plurality of movable lens groups are discontinued at the intermediate focal length. The zoom lens system is arranged to form an image on a predetermined image plane in accordance with a position of the moveable sub-lens group. The zoom path of the stepping zoom lens barrel shown in Figure 1 does not have a discontinuous portion at an intermediate focal length. Although the first through fourth lens groups L1 through L4 are shown as single lens elements in the lens-group-moving paths shown in Figure 1, each of the first through fourth lens groups L1 through L4

generally consists of more than one lens element.

【0011】

Figures 1 through 19 show the overall structure of the present embodiment of the zoom lens barrel of the present embodiment. As shown in Figures 2 through 5, a stationary barrel 11 which is fixed to a camera body is provided on an inner peripheral surface thereof with a female helicoid 11a and linear guide grooves 11b which extend parallel to an optical axis O. The female helicoid 11a of the stationary barrel 11 is engaged with a male helicoid 12a which is formed on an outer peripheral surface of the helicoid ring 12 in the vicinity of the rear end thereof. A second linear guide ring 13 is fitted in the helicoid ring 12 to be movable together with the helicoid ring 12 along the optical axis O and to be freely rotatable relative to the helicoid ring 12. Namely, the helicoid ring 12 is provided on an inner peripheral surface thereof with circumferential grooves 12c which extend in a circumferential direction of the helicoid ring 12, while the second linear guide ring 13 is provided on an outer peripheral surface thereof with guide projections 13a which are respectively engaged in the circumferential grooves 12c of the helicoid ring 12 to be freely movable therein. The circumferential grooves 12c and the guide projections 13a remain respectively an engaged state when the helicoid ring 12 and the second linear guide ring 13 is in use. The second linear guide ring 13 is provided at the rear end

engaged in an escape groove 13d which is formed on the second linear guide ring 13 to extend in a direction both in a circumferential direction of the second linear guide ring 13 and in the optical axis direction (the direction of the optical axis O). The guide pin 15b passes through the escape groove 13d to be engaged in a linear guide groove 12d, which is formed on an inner peripheral surface of the helicoid ring 12d (Figure 2) and extends parallel to the optical axis O. Therefore, a rotation of the helicoid ring 12 causes the cam ring 15 to move along the optical axis O while rotating about the optical axis O due to the engagement of the female helicoid 13c with the male helicoid 15a. The cam ring 15 is provided on an inner peripheral surface thereof with a female helicoid 15c (see Figures 2 and 6) and bottomed cam grooves 15d.

【0014】

A switching ring 16, a first lens group support ring 17 and a first linear guide ring 18 are fitted inside the cam ring 15 (Figure 9). Figure 7 is a developed view of the switching ring 16. The switching ring 16 and the first lens group support ring 17 move together along the optical axis O while the switching ring 16 is allowed to rotate freely about the optical axis O relative to the first lens group support ring 17. The first lens group support ring 17 is provided, on an outer peripheral surface thereof in the vicinity of the rear end of the first lens group support ring 17, with a male helicoid 17a,

thereof with radial projections 13b which are engaged in the plurality of linear guide grooves 11b of the stationary barrel 11.

【0012】

A spur gear 12b is provided on the thread of the male helicoid 12a, and this spur gear 12b is engaged with a drive pinion 14 which is provided in a recessed portion 11c (see Figure 2) formed on an inner peripheral surface of the stationary barrel 11 and is supported by the stationary barrel 11 to be freely rotatable therein. Accordingly, forward and reverse rotations of the drive pinion 14 cause the helicoid ring 12 to move forward rearward along the optical axis O while rotating about the optical axis O, thus causing the second linear guide ring 13 to move linearly along the optical axis O along with the helicoid ring 12.

【0013】

A cam ring 15 is fitted inside the second linear guide ring 13. Figure 6 is a developed view of an inner peripheral surface of the cam ring 15. The cam ring 15 is provided, on an outer peripheral surface thereof in the vicinity of the rear end of the cam ring 15, with a male helicoid 15a and a guide pin 15b which extends radially outwards from a portion of the male helicoid 15a. The male helicoid 15a is engaged with a female helicoid 13c formed on an inner peripheral surface of the second linear guide ring 13, while the guide pin 15b is

and is further provided immediately in front of the male helicoid 17a with a guide projection 17b which is engaged in a circumferential groove 16a (Figure 7) formed on an inner peripheral surface of the switching ring 16 in the vicinity of the rear end thereof to allow a relative rotation between the guide projection 17b and the circumferential groove 16a about the optical axis O.

【0015】

The male helicoid 17a of the first lens group support ring 17 is engaged with the female helicoid 15c of the cam ring 15. The rotation transfer projections 16b, which are formed on an outer peripheral surface thereof in the vicinity of the rear end of the switching ring 16, are engaged in rotation transfer grooves 15e which are formed on the inner peripheral surface of the cam ring 15 and extend parallel with the optical axis.

【0016】

On the other hand, guide projections 18a which are formed on an outer peripheral surface of the first linear guide ring 18 at the rear end thereof are engaged in linear guide grooves 13e formed on an inner peripheral surface of the second linear guide ring 13 and extend parallel to the optical axis. Furthermore, the first linear guide ring 18 is provided on an outer peripheral surface thereof with a linear guide groove 18b (see Figure 9) which extend parallel to the optical axis O, while the first lens group support ring 17 is provided, on an inner

peripheral surface thereof in the vicinity of the rear end of the first lens group support ring 17, with a linear guide projection 17c which projects radially inwards to be engaged in the linear guide groove 18b (Figure 9). Namely, each of the second linear guide ring 13, the first linear guide ring 18 and the first lens group support ring 17 is movable along the optical axis and does not rotate. Furthermore, the first linear guide ring 18 is provided in the immediate vicinity of the rear end thereof with an outer flange 18f (see Figure 9) which projects radially outwards to be engaged in a circumferential groove 15f (see Figure 6) which is formed on an inner peripheral surface of the cam ring 15 in the immediate vicinity of the rear end thereof so that a relative rotation between the outer flange 18f and the circumferential groove 15f about the optical axis is possible, and so that the outer flange 18f and the circumferential groove 15f move together in the optical axis direction.

【0017】

Therefore, if a rotation of the cam ring 15 is transferred to the switching ring 16 via the engagement of the rotation transfer projections 16b with the rotation transfer grooves 15e, the first lens group support ring 17, which has the male helicoid 17a engaged with the male helicoid 15c of the cam ring 15 and is prevented from rotating by the first linear guide ring 18, moves along the optical axis.

【0018】

A fourth lens group support ring 19 is supported by the first lens group support ring 17 to be freely movable linearly along the optical axis. Namely, the fourth lens group support ring 19 which supports the fourth lens group L4 is provided on an outer peripheral surface thereof with three axial arms 19a which extend parallel to the optical axis. The axial arms 19a are engaged in the linear guide slots 17d which are parallel to the optical axis.

【0019】

Furthermore, three linear guide arms 20a, which extend parallel to the optical axis, are formed on the periphery of the second/third lens group support block 20 which supports the second lens group L2 and the third lens group L3. The first linear guide ring 18 is provided with linear guide grooves 18c, which extend in a direction parallel to the optical axis, in which the linear guide arms 20a are engaged. Furthermore, the cam followers 20b which are fixed to the front ends of the linear guide arms 20a, are engaged in the bottomed cam grooves 15d of the cam ring 15. Figure 10 shows the second/third lens group support block 20 in an assembled state, while Figure 11 shows the second/third lens group support block 20 in a disassembled state. As shown in Figures 6 and 19, the bottomed cam grooves 15d have a photographing section (which includes the wide-angle mode section, the mode switching section and the telephoto mode

section which are shown in Figure 19) 15d1 for moving the second/third lens group support block 20 to a ready-to-photograph position, an accommodation section (accommodation position) 15d2 for positioning the second/third lens group support block 20 to an accommodation position thereof in which no photographing operation is performed, and a transfer section 15d3 for moving the second/third lens group support block 20 between the photographing section 15d1 and the accommodation section 15d2. The entire portion of the photographing section 15d1 and the entire portion of the transfer section 15d3 except for an end portion of the transfer section 15d3 in the vicinity of the accommodation section 15d2 are formed as narrow-width cam portions in which the associated cam follower 20b is engaged with a minimum clearance. The accommodation section 15d2 and the rear end portion of the transfer section 15d3 are formed as open cam portions. Accordingly, a rotation of the cam ring 15 causes the second/third lens group support block 20 to move linearly along the optical axis in accordance with the bottomed cam grooves 15d. The outer flange 18f of the first linear guide ring 18, which is engaged in the circumferential groove 15f of the cam ring 15 so that a relative rotation between the outer flange 18f and the circumferential groove 15f about the optical axis is possible, is provided with cut-out portions 18f' which are positioned behind the accommodation sections 15d2 to allow the cam followers 20b to enter the cut-out portions 18f'

(Figures 3, 9 and 18).

【0020】

A compression coil spring 31 for biasing the fourth lens group support ring 19 rearward is provided in between the second/third lens group support block 20 and the fourth lens group support ring 19. Each of the axial arms 19a is provided with an engaging projection 19b (Figure 8) which is engaged with an associated retaining projection 17e (Figures 8 and 9) which is formed on the first lens group support ring 17 at the rear end thereof to determine the rear limit for the axial movement of the fourth lens group support ring 19 with respect to the first lens group support ring 17 against the spring force of the compression coil spring 31 to prevent the fourth lens group support ring 19 from coming out of the first lens group support ring 17. The fourth lens group support ring 19 remains at its rearmost position with respect to the first lens group support ring 17 in a ready-to-photograph state of the zoom lens barrel 10.

【0021】

Operations of the above described portions of the zoom lens barrel 10 will be hereinafter discussed before the structure of the second/third lens group support block 20 is discussed in detail. Rotating the helicoid ring 12 by rotation of the drive pinion 14 causes the helicoid ring 12 to move along the optical axis O while rotating about the optical axis O, thus

causing the second linear guide ring 13, which is prevented from rotating, to move along the optical axis O together with the helicoid ring 12. This rotation of the helicoid ring 12 is transferred to the cam ring 15 to move the cam ring 15 along the optical axis together with the first linear guide ring 18, which is linearly guided, while rotating about the optical axis. This rotation of the cam ring 15 causes the switching ring 16 to move together with the first lens group support ring 17, which is linearly guided, along the optical axis while rotating about the optical axis. When the first lens group support ring 17 moves forward from its retracted position, the compression coil spring 31 resiliently expands gradually to position the fourth lens group support ring 19 at its rearmost position with respect to the first lens group support ring 17. This rearmost position corresponds to wide-angle extremity in the zooming range. Thereafter the first lens group support ring 17 and the fourth lens group support ring 19 move together. Since the first lens group support ring 17 and the fourth lens group support ring 19 hold the first lens group L1 and the fourth lens group L4, respectively, the first lens group L1 and the fourth lens group L4 move together along the optical axis O to be linearly proportional to the angle of rotation of the helicoid ring 12 (without varying the distance between the first lens group L1 and the fourth lens group L4) as shown in Figure 1.

【0022】

Furthermore, in the accommodation position, as can be clearly seen in Figure 3, a front end surface of the second/third lens group support block 20 is positioned very closely to or comes in contact with a rear end surface of a first lens frame 29 by which the first lens group L1 is fixed to be supported. The first lens frame 29 is fixed to a front end portion of the first lens group support ring 17. In this state, since the rear of the accommodation section 15d2 of each cam groove 15d is open, each cam follower 20b is disengaged from a front cam surface in the associated cam groove 15d to become capable of moving rearward to thereby reduce the length of the lens barrel in the retracted state when the second/third lens group support block 20 is pressed rearward by the first lens frame 29 against the spring force of the compression coil spring 31. At the same time, a fourth lens frame 30, to which the fourth lens group L4 is fixed to be supported thereby, is moved rearward to the position where the fourth lens frame 30 contacts with a light shield plate 35 (see Figure 3) by the spring force of the compression coil spring 31. The fourth lens frame 30 is fixed to the fourth lens group support ring 19, while the light shield plate 35 is fixed to a rear end surface of the helicoid ring 12.

【0023】

On the other hand, the axial position of the second/third lens group support block 20, which is linearly guided by the

first linear guide ring 18, is restricted (determined) by the bottomed cam grooves 15d formed on an inner peripheral surface of the cam ring 15. The second/third lens group support block 20 supports the second lens group L2 and the third lens group L3, while a continuous rotation of the cam ring 15 together with the switching ring 16 provides the second lens group L2 and the third lens group L3 respective moving paths thereof shown in Figure 1. The structure of the second/third lens group support block 20, and associated structures of the cam ring 15 and the switching ring 16 will be hereinafter discussed in detail with reference to Figures 9 through 18.

【0024】

The linear guide arms 20a and the cam followers 20b are formed on the second/third lens group moving ring 21. The second lens frame 23 which supports the second lens group L2, a third lens frame 24 which supports the third lens group L3, a differential linking ring 25, a differential ring 26 and a differential spring 27 are provided between the second/third lens group moving ring 21 and the front-end pressing plate 22, in that order from the object side. Linear guide pins 22a are fixed to the front-end pressing plate 22 to extend rearward to be parallel to the optical axis. The second lens frame 23 is provided with guide bosses 23a which are slidably fitted on the linear guide pins 22a. Compression springs 22b are loosely fitted on the linear guide pins 22a to press the second lens

frame 23 rearward.

【0025】

Each of the third lens frame 24, the differential linking ring 25 and the differential ring 26 is rotatable about the optical axis O. The second lens frame 23 and the third lens frame 24 have cylindrical portions so that the cylindrical portion of the third lens frame 24 is fitted on the cylindrical portion of the second lens frame 23. The second lens frame 23 is provided on an outer peripheral surface of the cylindrical portion thereof with inclined cam edges 23b, and the third lens frame 24 is provided on an inner peripheral surface of the cylindrical portion thereof with cam followers 24a which are engaged with the set of four inclined cam edges 23b. Each cam edge 23b extends linearly, and is inclined with respect to both a circumferential direction of the second lens frame 23 and the optical axis direction. The third lens frame 24 is provided on an outer peripheral surface thereof with a pair of rotation transfer projections 24b, and the differential linking ring 25 is provided on an inner peripheral surface thereof with a pair of rotation transfer grooves 25a in which the pair of rotation transfer projections 24b are engaged, so that the third lens frame 24 and the differential linking ring 25 rotate together at all times. The third lens frame 24 is always pressed rearward by the spring force of the pair of compression springs 22b to be in pressing contact with the second/third lens group moving

ring 21 to determine the position of the third lens frame 24 in the optical axis direction. Furthermore, the differential ring 26 is provided on an inner peripheral surface thereof with a pair of forced-rotation transfer grooves 26a, and the differential linking ring 25 is provided on an outer peripheral surface thereof with a pair of forced-rotation transfer projections 25b which are engaged in the pair of forced-rotation transfer grooves 26a with a predetermined circumferential clearance between each forced-rotation transfer projection 25b and the associated forced-rotation transfer groove 26a (Figures 16 and 17).

【0026】

The differential spring 27 is a torsion spring consisting of a loop portion 27a with its center substantially on the optical axis and a pair of leg portions 27b which project radially outwards from the opposite ends of the loop portion 27a. The loop portion 27a is fitted in the differential linking ring 25 to be engaged with an inner peripheral surface thereof by friction. The differential linking ring 25 is provided with radial spring holes 25c into which the pair of leg portions 27b are inserted from the inside of the differential linking ring 25 to project radially outwards from an outer peripheral surface of the differential linking ring 25. The differential linking ring 25 is provided on an inner peripheral surface thereof with an inward projection 25d (see Figure 11) which is engaged with

the loop portion 27a of the differential spring 27 to prevent the differential spring 27 from coming off the differential linking ring 25. The differential ring 26 is provided with a rotation transfer projection 26b which projects rearwards, and the pair of leg portions 27b of the differential spring 27 are in pressing in contact with opposite surfaces of the rotation transfer projection 26b in a circumferential direction of the differential ring 26 in opposite directions towards each other. The differential linking ring 25 normally rotates together with the differential ring 26 via the differential spring 27 when the differential ring 26 rotates. However, if the differential linking ring 25 reaches one end of the range of rotation thereof (i.e., if a resistance which is generated in the differential linking ring 25 to rotate is greater than a predetermined resistance) when the differential ring 26 rotates, the differential ring 26 rotates relative to the differential linking ring 25 while the differential spring 27 is deformed to open the pair of leg portions 27b.

【0027】

A switching leaf 28 is provided on an inner peripheral surface thereof with a rotation transfer groove 28a which extends parallel to the optical axis, while the rotation transfer projection 26b is provided with a linking pin 26c which projects radially outwards to be engaged in the rotation transfer groove 28a. As shown in Figure 9, the switching leaf

28 is positioned in a receiving groove 18d formed on the first linear guide ring 18, and is supported by the first linear guide ring 18 to be movable in a circumferential direction of the first linear guide ring 18 with respect to the first linear guide ring 18 within a predetermined angle of rotation. The switching ring 16 is provided on an inner peripheral surface thereof with a switching groove 16c, while the switching leaf 28 is provided, on an outer peripheral surface thereof in the vicinity of the front end of the switching leaf 28, with a follower projection 28b which is engaged in the switching groove 16c.

【0028】

As shown in Figures 7 and 18, the switching groove 16c consists of a telephoto section 16cT, a switching section 16cK and a wide-angle section 16cW. Each of the telephoto section 16cT and the wide-angle section 16cW have the same lead angle as that of the threads of the female helicoid 15c of the cam ring 15 but are opposite in direction. The switching section 16cK extends parallel to the optical axis. Therefore, when the cam ring 15 and the switching ring 16 rotate together, the switching leaf 28 does not rotate relative to the first linear guide ring 18 as long as the follower projection 28b of the switching leaf 28 remains engaged in either the telephoto section 16cT or the wide-angle section 16cW. However, in the case where the follower projection 28b of the switching leaf 28 is engaged in the switching section 16cK, the switching leaf

28 rotates relative to the first linear guide ring 18. Due to this relative rotation, the distance between the second lens group L2 and the third lens group L3 is maintained at a distant position, and the distance between the second lens group L2 and the third lens group L3 is maintained at close position at the telephoto range.

【0029】

As shown in Figures 14 and 15, the third lens frame 24 is provided with a rotational range limit groove 24c and the second/third lens group moving ring 21 is provided with a stop projection 21a which is engaged in the rotational range limit groove 24c to limit the rotational angle of the third lens frame 24 relative to the second/third lens group moving ring 21 to a sufficient range for the third lens frame 24 to be switched between the wide-angle position and the telephoto position. The rotational angle of a combination of the switching leaf 28 and the differential ring 26 is determined to be greater than that of the third lens frame 24, and the difference therebetween is absorbed by the differential spring 27.

【0030】

If the switching leaf 28 is rotated counterclockwise from the position shown in Figure 16 to the position shown in Figure 17, via the engagement of the follower projection 28b with the switching groove 16c in a state shown in Figure 14 where the second lens group L2 and the third lens group L3 are distant

from each other in the optical axis direction, the differential ring 26 rotates. This rotation of the differential ring 26 is transferred to the differential linking ring 25 via the engagement of the pair of leg portions 27b of the differential spring 27 with the rotation transfer projection 26b to rotate the third lens frame 24 in the same rotational direction as the differential ring 26. This rotation of the third lens frame 24 causes the rotational range limit groove 24c to come into contact with the stop projection 21a to thereby prevent the differential linking ring 25, which rotates together with the third lens frame 24, from further rotating together with the third lens frame 24. Even after the differential linking ring 25 is prevented from rotating, the differential ring 26 continues to rotate in the same rotational direction. This overcharge of the differential ring 26 is absorbed by a resilient deformation of the differential spring 27. The rotation of the third lens frame 24 causes the second lens frame 23, which is biased rearward by the pair of compression springs 22b, to move rearward due to the engagement of the set of four cam followers 24a with the set of four inclined cam edges 23b, thus causing the second lens group L2 and the third lens group L3 to approach each other (see Figures 15 and 17). The pair of forced-rotation transfer projections 25b are tightly engaged with the pair of forced-rotation transfer grooves 26a, respectively, to forcibly transfer rotation of the differential

ring 26 to the differential linking ring 25 in the event of the pair of leg portions 27b of the differential spring 27 being open due to a resistance in the differential linking ring 25 from rotating caused by some reason.

【0031】

If the switching leaf 28 is rotated reversely, i.e., clockwise from the position shown in Figures 15 and 17, the second lens group L2 and the third lens group L3 move apart from each other. The overcharge operations of the differential ring 25, the differential linking ring 26 and the differential spring 27 are the same as those described above when the switching leaf 28 is rotated in the forward direction (counterclockwise). Each inclined cam edge 23b is provided on opposite ends thereof with a recess 23b1 and a recess 23b2 for holding the associated cam follower 24a at a telephoto mode position and a wide-angle mode position with stability. Furthermore, four inclined cam edges 23b each having the recesses 23b1 and 23b2 on opposite ends thereof are arranged at equi-angular intervals in a circumferential direction of the second lens frame 23 (i.e., a circumferential direction of the third lens frame 24) to ensure precision in spacing (i.e., the distance) between the second lens group L2 and the third lens group L3 and the precision in positioning the second lens group L2 and the third lens group L3 concentrically with the optical axis.

【0032】

Note that in the above-described zoom lens barrel, a shutter unit 32 which is fixed immediately behind to the second/third lens group moving ring 21, and a flexible printed wiring board (flexible PWB) 33 for electrically connecting the shutter unit 32 to a control circuit of the camera body extends from the shutter unit 32. Furthermore, a light shield bellows 34 is positioned in between an inner peripheral surface of the first lens frame 17 in the vicinity of the front end thereof and a front surface of the second/third lens group support block 20.

【0033】

The focusing operation of the step zoom lens barrel will be hereinafter discussed based on Figure 19. In the present embodiment of the zoom lens barrel, focusing is performed via the bottomed cam grooves 15d of the cam ring 15 (via rotation of the cam ring 15). Accordingly, the step-zoom lens barrel has four different focal lengths (steps 1, 2, 3 and 4) in the wide-angle mode and two different focal lengths (steps 5 and 6) in the telephoto mode, giving a total of six focal length steps. The contours of the cam grooves 15d are determined so as to move the second/third lens group support block 20 (the second lens group L2 and the third lens group L3) between a closest photographing position (N) and an infinite photographing position (∞) in the optical axis direction at each of the six different focal lengths. More specifically,

each cam groove 15d includes a step-1 position for the infinite photographing position (∞), a step-1 position for the closest photographing position (N), a step-2 position for the closest photographing position (N), a step-2 position for the infinite photographing position (∞), a step-3 position for the infinite photographing position (∞), a step-3 position for the closest photographing position (N), a step-4 position for the closest photographing position (N), a step-4 position for the infinite photographing position (∞), the mode switching section, a step-5 position for the infinite photographing position (∞), a step-5 position for the closest photographing position (N), a step-6 position for the closest photographing position (N), and a step-6 position for the infinite photographing position (∞), in that order in a rotating direction of the cam ring 15. The angle of rotation (the angular position of the cam ring 15) of the cam ring 15 is controlled in accordance with information on a set focal length and an object distance.

【0034】

Accordingly, each cam groove 15d is formed so that the closest photographing positions (N) in two adjacent focal-length step positions are adjacent to each other, and the infinite photographing positions (∞) in two adjacent focal-length step positions are adjacent to each other. This structure is advantageous to simplify the contour of each cam groove 15d and to shorten the length thereof.

【0035】

The above described embodiment of the zoom lens barrel includes: the first linear guide ring 18 which is supported to be linearly movable along the optical axis without rotating; the first lens group support ring (moving frame) 17 which is supported by the first linear guide ring 18 to be linearly movable along the optical axis without rotating and is provided on an outer peripheral surface of the lens group support ring 17 with the male helicoid; a cam ring (rotatable ring) 15 which is coupled to the first linear guide ring 18 at a predetermined relative rotational position between the cam ring 15 and the first linear guide ring 18 to be freely rotatable relative to the first linear guide ring 18 without moving along the optical axis O relative to the first linear guide ring 18 and is provided on an inner peripheral surface of the cam ring 15 with the female helicoid 15c which is engaged with the male helicoid 17a of the lens group support ring 17; the switching ring 16 that is coupled to the cam ring 15 to be freely movable along the optical axis relative to the cam ring 15 and rotatable together with the cam ring 15 and is coupled to the lens group support ring 17 at a predetermined relative rotational position between the switching ring 16 and the lens group support ring 17 to be freely rotatable relative to the lens group support ring 17 without moving along the optical axis relative to the lens group support ring 17; the switching leaf 28 which is supported by the first

linear guide ring 18 to be freely movable in a circumferential direction of the first linear guide ring 18 within a predetermined range of movement without moving along the optical axis relative to the first linear guide ring 18; and the switching groove (switching-member moving groove) 16c which is formed on an inner peripheral surface of the switching ring 16 to be engaged with the follower projection 28b projecting from the switching leaf 28. The switching groove 16c which is formed as a bottomed groove includes the telephoto section (first inclined section) 16cT, the switching section 16cK, a wide-angle section (second inclined section) 16cW and an assembling section 16cA, in that order from rear of the zoom lens barrel. The telephoto section 16cT is shaped so that the lead angle thereof is the same as that of the threads of the female helicoid 15c of the cam ring 15 and so that the direction of inclination of the telephoto section 16cT is opposite to that of the threads of the female helicoid 15c of the cam ring 15. The switching section 16cK is shaped to extend parallel to the optical axis O from the front end of the telephoto section 16cT. The wide-angle section 16cW is shaped to extend parallel to the telephoto section 16cT from the front end of the switching section 16cK. The assembling section 16cA extends rearwards from the front end of the wide-angle section 16cW to be parallel to the optical axis O (see Figure 7).

【0036】

The assembling groove 16cA serves to make the first linear guide ring 18 and the cam ring 15 coupled in a bayonet manner, to make the lens group support ring 17 and the switching ring 16 coupled in a bayonet manner, and to make the lens group support ring 17 and the cam ring 15 coupled in a helicoid manner. Figures 20 through 43 show assembling procedures of the zoom lens barrel.

【0037】

Figure 20 is a longitudinal cross sectional view of an upper portion of the zoom lens barrel, showing a state of the second/third lens group support block 20 before being fitted into the first linear guide ring 18 from the image side, and Figure 21 is a developed view of the first linear guide ring 18 and the second/third lens group support block 20. In this state, the linear guide arms 20a of the second/third lens group support block 20 are inserted into the linear guide grooves 18c of the first linear guide ring 18 to be freely slidable therein. Figure 22 is a longitudinal cross sectional view of an upper portion of the zoom lens barrel, showing a state of the second/third lens group support block 20 after being fitted into the first linear guide ring 18. In this state, the set of three cam followers 20b are snugly fitted into the pin holes 20b', which are exposed radially outwards from the linear guide grooves 18c. Engaging the cam followers 20b into the linear guide arms 20a in such a manner prevents the second/third lens

group support block 20 from coming off the first linear guide ring 18.

【0038】

Figure 23 shows the portion of the zoom lens barrel shown in Figure 22 before being fitted into the first lens group support ring 17 from the object side. Figure 24 is a developed view of the assembly shown in Figure 23. In this state, the linear guide projection 17c of the first lens group support ring 17 is inserted into the linear guide groove 18b of the first linear guide ring 18 to be freely slidable therein. Figures 25 and 26 show an upper cross sectional view of the zoom lens barrel and a developed view thereof, respectively, which both show assembled states of the zoom lens barrel. In this state, the receiving groove 18d of the first linear guide ring 18 is exposed radially outwards through a through opening 17f which is formed on the first lens group support ring 17.

【0039】

Figure 27 shows a manner of mounting the switching leaf 28 to be positioned in the receiving groove 18d through the through opening 17f of the first lens group support ring 17. In this state, the linking pin 26c which projects radially outwards from the rotation transfer projection 26b of the second/third lens group support block 20 is engaged in the rotation transfer groove 28a of the switching leaf 28.

【0040】

After the switching leaf 28 has been mounted to the first linear guide ring 18 in the above described manner, as shown in Figure 28, the first lens group support ring 17 is drawn from the assembly shown in Figure 27 to prepare for the switching ring 16 to be fitted on the first lens group support ring 17. From this state, the switching ring 16 is fitted on the first lens group support ring 17 (Figure 29). Since the bottomed switching groove 16c (which includes the telephoto section 16cT, the switching section 16cK, the wide-angle section 16cW and the assembling section 16cA in that order from the rear of the zoom lens barrel) is formed on an inner peripheral surface of the switching ring 16 and since the rear end of the telephoto section 16cT is open on a rear end surface of the switching ring 16, the follower projection 28b of the switching leaf 28 can be inserted into the switching groove 16c through the open rear end of the telephoto section 16cT (Figures 30 and 31).

【0041】

At the same time, the guide projection 17b of the first lens group support ring 17 is engaged in the circumferential groove 16a of the switching ring 16. In this state, if the switching ring 16 and the first lens group support ring 17 are rotated relative to each other by a predetermined amount of movement, the switching ring 16 and the first lens group support ring 17 are coupled (in a bayonet manner) to be freely rotatable relative to each other and to be movable together. In the state

shown in Figure 30, the switching ring 16 is positioned at the rearmost position relative to the first lens group support ring 17, and is therefore impossible to further move rearward relative to the first lens group support ring 17.

【0042】

Figures 32 and 33 are an upper cross-sectional view and a developed view thereof, respectively, showing a state where the first lens group support ring 17 (on which the switching ring 16 is fitted) is fitted on the first linear guide ring 18 and fully moved up to the rearmost position relative to the first linear guide ring 18, while the switching ring 16 is being rotated relative to the first lens group support ring 17 clockwise as viewed from the object side (in a direction shown by an arrow A in Figure 33) from the state shown in Figures 30 and 31. In this state, the switching ring 16 and the first lens group support ring 17 are movable together along the optical axis while the switching ring 16 is allowed to rotate freely about the optical axis relative to the first lens group support ring 17.

【0043】

Figures 34 and 35 are an upper cross-sectional view and a developed view thereof, respectively, showing a state where a combination of the switching ring 16 and the first lens group support ring 17 is drawn from the first linear guide ring 18 of the state shown in Figures 32 and 33. It is possible to

draw the combination of the switching ring 16 and the first lens group support ring 17 from the first linear guide ring 18 because the switching groove 16c is formed to include the assembling section 16cA. Namely, the follower projection 28b of the switching leaf 28 moves from the end of the wide-angle section 16cW to the rear end of the assembling section 16cA. It should be noted that the switching leaf 28 is supported by the first linear guide ring 18 to be immovable in the guide slot 18d in the optical axis direction and to be movable in the guide slot 18d in a circumferential direction of the first linear guide ring 18 within a predetermined range of movement.

【0044】

The combination of the switching ring 16 and the first lens group support ring 17 is drawn from the first linear guide ring 18 in a manner described above so as to engage the female helicoid 15c of the cam ring 15 with the male helicoid 17a of the first lens group support ring 17 and further to couple the cam ring 15 to the first linear guide ring 18 in a bayonet manner so that the cam ring 15 is freely rotatable relative to the first linear guide ring 18 and movable together with the first linear guide ring 18 in the optical axis direction. Namely, the circumferential groove 15f is formed on the cam ring 15 on an inner peripheral surface thereof in the vicinity of the rear end of the cam ring 15, while the outer flange 18f is formed on an outer peripheral surface of the first linear guide ring

18 in the vicinity of the rear end of the first linear guide ring 18. The outer flange 18f is provided with cutout portions 18g at predetermined angular positions, while the cam ring 15 is provided immediately behind the circumferential groove 15f with a corresponding plurality of engaging projections (bayonet lugs) 15g (see Figures 37, 41 and 43). The outer flange 18f can be engaged in the circumferential groove 15f if the cam ring 15 and the first linear guide ring 18 are moved relative to each other along the optical axis in opposite directions to bring the circumferential groove 15f and the outer flange 18f close to each other with the plurality of engaging projections (bayonet lugs) 15g and the plurality of cutout portions 18g aligned in the optical axis direction.

【0045】

Figures 36 and 37 are an upper cross-sectional view and a developed view thereof, respectively, showing a manner of fitting the cam ring 15 on the assembly shown in Figures 34 and 35 from the object side. The female helicoid 15c, which is engaged with the male helicoid 17a of the first lens group support ring 17, and the rotation transfer grooves 15e, in which the rotation transfer projections 16b of the switching ring 16 are respectively engaged, are formed on an inner peripheral surface of the cam ring 15. The rotation transfer projections 16b are positioned at equi-angular intervals on an outer peripheral surface of the switching ring 16 at the rear end

thereof, and the rotation transfer grooves 15e are formed to correspond to the rotation transfer projections 16b via cut-out portions of the female helicoid 15c to correspond to the rotation transfer projections 16b. In Figures 36 and 37, the cam ring 15 and the switching ring 16 are positioned relative to each other so that the rotation transfer projections 16b and the rotation transfer grooves 15e are aligned. However, in this state, the plurality of engaging projections (bayonet lugs) 15g and the plurality of cutout portions 18g are not aligned.

【0046】

Figures 38 and 39 are an upper cross-sectional view and a developed view thereof, respectively, showing a state where the cam ring 15 is fitted on the switching ring 16 so that the rotation transfer projections 16b are respectively engaged with the rotation transfer grooves 15e. In this state, the switching ring 16 rotates synchronously with the cam ring 15 whenever rotating.

【0047】

Figures 40 and 41 are an upper cross-sectional view and a developed view thereof, respectively, showing a state where the male helicoid 17a of the first lens group support ring 17 is engaged with the female helicoid 15c of the cam ring 15 by rotating the cam ring 15 relative to the first lens group support ring 17 clockwise as viewed from the object side (in a direction shown by an arrow B in Figure 41) from the state shown in Figures

38 and 39. Such an engagement of the male helicoid 17a with the female helicoid 15c is possible because the combination of the switching ring 16 and the first lens group support ring 17 has been drawn from the first linear guide ring 18 as shown in Figure 38. If the combination of the switching ring 16 and the first lens group support ring 17 is not drawn from the first linear guide ring 18, the plurality of engaging projections (bayonet lugs) 15g of the cam ring 15 interfere with the outer flange 18f to prevent the male helicoid 17a and the female helicoid 15c from engaging with each other.

【0048】

Subsequently, the cam ring 15 and the first linear guide ring 18 are rotated relative to each other with the female helicoid 15c being engaged with the male helicoid 17a so that the plurality of engaging projections (bayonet lugs) 15g and the plurality of cutout portions 18g are aligned. In this state, the outer flange 18f can engage in the circumferential groove 15f by moving the cam ring 15 and the first linear guide ring 18 relative to each other along the optical axis. Figures 42 and 43 are an upper cross-sectional view and a developed view thereof, respectively, showing a state where the assembly is in a completely assembled state.

【0049】

Figure 44 shows an comparative example of an assembly in the case where the switching groove 16c of the switching ring

16 does not include the assembling section 16cA. In this example, an assembly of the cam ring 15, the switching ring 16 and the first lens group support ring 17 cannot be drawn out from the first linear guide ring 18. Therefore, when the female helicoid 15c of the cam ring 15 is brought into engagement with the male helicoid 17a of the first lens group support ring 17, the male helicoid 17a of the first lens group support ring 17 cannot be engaged with the female helicoid 15c of the cam ring 15 because the engaging projections (bayonet lugs) 15g of the cam ring 15 hit the outer flange 18f of the first linear guide ring 18.

【0050】

The present invention can be applied not only to the zoom lens system shown in Figure 1 of the above described embodiment but also to a lens system having an ordinary switching mechanism as long as such a lens system includes: a linear guide ring, a rotatable ring, a switching ring and a moving frame, wherein the linear guide ring and the rotatable ring are coupled in a bayonet manner (in a manner so that the rotatable ring is freely rotatable relative to the linear guide ring and so that the rotatable ring and the linear guide ring are movable together along an optical axis) while the switching ring and the moving frame which rotate together with the rotatable ring are coupled in a bayonet manner (in a manner so that the switching ring is freely rotatable relative to the moving frame and so that the

switching ring and the moving frame are movable together along an optical axis), wherein the moving frame and the rotatable ring are coupled in a helicoid manner, wherein a switching leaf is supported by the linear guide ring to be freely movable in a circumferential direction of the linear guide ring within a predetermined range of movement without moving along the optical axis relative to the linear guide ring, and wherein a switching-member moving groove is formed on an inner peripheral surface of the switching ring to be engaged with a follower projection which projects from the switching leaf.

【0051】

【EFFECTS OF THE INVENTION】

According to the present invention, in a lens barrel wherein a linear guide ring and a rotatable ring are coupled in a bayonet manner (in a manner so that the rotatable ring is freely rotatable relative to the linear guide ring and so that the rotatable ring and the linear guide ring are movable together along an optical axis) while a switching ring and a moving frame which rotate together with the rotatable ring are coupled in a bayonet manner (in a manner so that the switching ring is freely rotatable relative to the moving frame and so that the switching ring and the moving frame are movable together along an optical axis), and wherein the moving frame and the rotatable ring are coupled in a helicoid manner, an assembling operation for making a switching leaf supported by

the linear guide ring to be freely movable in a circumferential direction of the linear guide ring within a predetermined range of movement without moving along the optical axis relative to the linear guide ring and further for engaging a follower projection which projects from the switching leaf in a switching-member moving groove which is formed on an inner peripheral surface of the switching ring can be performed without any difficulties arising.

【BRIEF DESCRIPTION OF THE DRAWINGS】

Figure 1 is a diagram showing the lens-group zooming path of a step-zoom lens system, which includes a switching lens group, of a zoom lens barrel according to the present invention;

Figure 2 is an exploded perspective view of an embodiment of the zoom lens barrel according to the present invention;

Figure 3 is an upper cross sectional view of the zoom lens barrel shown in Figure 2 in a retracted state;

Figure 4 is an upper cross sectional view of the zoom lens barrel shown in Figure 2 at the wide-angle extremity which is focused on an image at infinity;

Figure 5 is an upper cross sectional view of the zoom lens barrel shown in Figure 2 at telephoto extremity which is focused on an image at infinity;

Figure 6 is a developed view of an inner peripheral surface of a cam ring of the zoom lens barrel shown in Figure 2;

Figure 7 is a developed view of an inner peripheral surface of a switching ring of the zoom lens barrel shown in Figure 2;

Figure 8 is an upper cross sectional view of a portion of the zoom lens barrel shown in Figure 2, showing a structure of engagement of a first lens group support ring with a fourth lens frame;

Figure 9 is a developed perspective view of the switching ring, the first lens group support ring and a first linear guide ring of the zoom lens shown in Figure 2;

Figure 10 is a perspective view of a second/third lens group support block of the zoom lens barrel shown in Figure 2;

Figure 11 is an exploded perspective view of the second/third lens group support block shown in Figure 10;

Figure 12 is a longitudinal cross sectional view of a switching mechanism of the zoom lens barrel shown in Figure 2 that includes the second/third lens group support block shown in Figure 10;

Figure 13 is a perspective view of an overcharge mechanism incorporated in the second/third lens group support block shown in Figure 10;

Figure 14 is a developed view of the second/third lens group support block in a wide-angle mode;

Figure 15 is a developed view of the second/third lens group support block in a telephoto mode;

Figure 16 is a front elevational view of the second/third lens group support block in a wide-angle mode;

Figure 17 is a front elevational view of the second/third lens group support block in a telephoto mode;

Figure 18 shows developed views of the second/third lens group support block in a switching state between wide-angle mode and telephoto mode;

Figure 19 is a developed view of a cam profile provided on a cam ring;

Figure 20 is an upper cross sectional view of a portion of the zoom lens barrel showing a state of the second/third lens group support block before it is fitted into the first linear guide ring from the image side;

Figure 21 is a developed view of Figure 20;

Figure 22 is an upper cross sectional view of a portion of the zoom lens barrel showing a state of the second/third lens group support block after it has been fitted into the first linear guide ring;

Figure 23 is an upper cross sectional view of a portion of the zoom lens barrel showing a state of the assembly shown in Figure 22 before it is fitted into the first lens group support ring from the object side;

Figure 24 is a developed view of Figure 23;

Figure 25 is an upper cross sectional view of a portion of the zoom lens barrel after the first lens group support ring

has been fitted into the first linear guide ring;

Figure 26 is a developed view of Figure 25;

Figure 27 is an upper cross sectional view of the assembly shown in Figure 25 showing a manner of mounting the switching leaf to the assembly shown in Figure 25 in a radial direction thereof;

Figure 28 is an upper cross sectional view of the assembly shown in Figure 25 showing a state where the first lens group support ring is drawn from the assembly shown in Figure 27 along the optical axis to a position at which the switching ring is made to fit on the first lens group support ring;

Figure 29 is an upper cross sectional view of the assembly shown in Figure 28 and the switching ring, showing a manner of fitting the switching ring on the first lens group support ring from the object side;

Figure 30 is an upper cross sectional view showing a state wherein the follower projection of the switching leaf is engaged in the bottomed switching groove of the switching ring, and in a state where the switching ring is positioned in a bayonet engagement position with the first lens group supporting ring;

Figure 31 is a developed view of Figure 30;

Figure 32 is an upper cross sectional view showing a state where the switching ring is fitted is fully fitted on the first linear guide ring while being rotated from the state shown in Figure 30;

Figure 33 is a developed view of Figure 32;

Figure 34 is an upper cross sectional view showing a state where a combination of the first lens group support ring and the switching ring is drawn from the first linear guide ring in a direction toward the object side along the optical axis;

Figure 35 is a developed view of Figure 34;

Figure 36 is an upper cross sectional view of the assembly shown in Figure 34 and the cam ring, showing a manner of fitting the cam ring on the assembly shown in Figure 34 from the object side;

Figure 37 is a developed view of Figure 36;

Figure 38 is an upper cross sectional view showing a state where the cam ring is fitted on the switching ring of the assembly shown in Figure 36 from the object side;

Figure 39 is a developed view of Figure 38;

Figure 40 is an upper cross sectional view showing a state where the male helicoid of the first lens group support ring is engaged with the female helicoid of the cam ring by rotating the cam ring;

Figure 41 is a developed view of Figure 39;

Figure 42 is an upper cross sectional view showing a completely assembled state;

Figure 43 is a developed view of Figure 42; and

Figure 44 is an upper cross sectional view showing a comparative example of an assembly in the case where the

switching groove of the switching ring does not include an assembling groove.

【BRIEF DESCRIPTION OF THE REFERENCE NUMERALS】

L1 First lens group

L2 Second lens group

L3 Third lens group

L4 Fourth lens group

L23 Distance-varying lens group

11 Stationary barrel

11a Female helicoid

11b Linear guide grooves

11c Recessed portion

12 Helicoid ring

12a Male helicoid

12b Spur gear

12c Circumferential grooves

12d Linear guide groove

13 Second linear guide ring

13a Guide projections

13b Radial projections

13c Female helicoid

13d Escape groove

14 Drive pinion

15 Cam ring

15a Male helicoid

15b Guide pin

15c Female helicoid

15d Bottomed cam groove

15e Rotation transfer grooves

15f Circumferential groove 15f

15g Engaging projections (bayonet lugs)

16 Switching ring

16a Circumferential groove

16b Rotation transfer projections

16c Bottomed switching groove (switching leaf moving mechanism)

16cT Telephoto section

16cK Switching section

16cW Wide-angle section

16cA Assembling section

17 First lens group support ring (moving frame)

17a Male helicoid

17b Guide projection

17c Linear guide projection

17e Retaining projection

18 First linear guide ring (linear guide ring)

18a Guide projections

18b Linear guide groove

18c Linear guide grooves

18d Receiving groove

18f Flange

18f′ Cutout portions

18g Cutout portions

19 Fourth lens group support ring

19a Axial arms

19b Engaging projection

20 second/third lens group support block (second lens group block)

20a Linear guide arms

21 Second/third lens group moving ring

21a Stop projection

22 Front-end pressing plate

22a Linear guide pins

22b Compression springs

23 Second lens frame

23a Guide boss

23b Inclined cam surface

24 Third lens frame (rotational lens frame)(distance switching mechanism)

24a Follower projection

24b Rotation transfer projections

24c Rotational range limit groove

25 Differential linking ring (linear lens frame)(distance switching mechanism)

25a Rotation transfer grooves

25b Forced-rotation transfer projections

25c Spring holes

26 Differential ring (distance switching mechanism)

26a Forced-rotation transfer grooves

26b Rotation transfer projection

26c Linking pin (switching leaf moving mechanism)

27 Differential spring

27b Pair of leg portions

28 Switching leaf

28a Rotation transfer groove

28b Follower projection

29 First lens frame

30 Fourth lens frame

31 Compression spring

32 Shutter block

33 FPC board

34 Light shield bellows

35 Light shield plate

【TITLE OF THE DOCUMENT】 ABSTRACT

【ABSTRACT】

【OBJECTIVE】 In a lens barrel in which a linear guide ring and a rotatable ring are coupled in a bayonet manner (in a manner so that the rotatable ring is freely rotatable relative to the

linear guide ring and so that the rotatable ring and the linear guide ring are movable together along an optical axis) and a switching ring and a moving frame which rotate together with the rotatable ring are coupled in a bayonet manner (in a manner so that the switching ring is freely rotatable relative to the moving frame and so that the switching ring and the moving frame are movable together along an optical axis), and wherein the moving frame and the rotatable ring are coupled in a helicoid manner, an assembling operation for making a switching leaf supported by the linear guide ring to be freely movable in a circumferential direction of the linear guide ring within a predetermined range of movement without moving along the optical axis relative to the linear guide ring and further for engaging a follower projection which projects from the switching leaf in a switching-member moving groove which is formed on an inner peripheral surface of the switching ring can be performed.

【CONSTRUCTION】 A switching leaf moving groove includes a first inclined section (16cT) in which the switching leaf follower projection, which is shaped so that a lead angle thereof is the opposite of the threads of the female helicoid of the rotatable ring, is inserted; a switching section (16cK) which is shaped to extend parallel to the optical axis from a front end of the first inclined section; a second inclined section (16cW) which is shaped to extend parallel to the first

inclined section from a rear end of the switching section; and an assembling section (16cA) which extends rearwards from a front end of the second inclined section to be parallel to the optical axis, in that order from rear of the lens barrel switching/moving structure.

【SELECTED FIGURE】 Figure 1